DECLARATION

I, Masaki Akashi, Bachelor of Mechanical Engineering and Patent Attorney of Japan, of Akashi & Co., Patent Attorneys Office, 5th floor, YH Bldg., 2-6-8 Shinkawa, Chuo-ku, Tokyo, Japan, do solemnly and sincerely declare that I am well acquainted with the Japanese and English languages, and that the attached is a true and correct translation into English of the full descriptions of the certificate of Japanese Patent Application Heisei 10-347130 issued by the Japanese Patent Office on 17 June 1999 with the certificate No. 11-3042259.

I hereby declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Declared at Tokyo, Japan
2nd day of April, 2004

Masaki Akashi

PATENT OFFICE

JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Applicant: TOYOTA JIDOSHA KABUSHIKI KAISHA

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Commissioner, Patent Office

Takeshi Isayama

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【Inventor】	
【Address】	c/o Toyota Jidosha Kabushiki Kaisha 1 Toyotacho, Toyota-shi, Aichi-ken
【Name】	Akira Nagae
【Inventor】	
【Address】	c/o Toyota Jidosha Kabushiki Kaisha 1 Toyotacho, Toyota-shi, Aichi-ken
【Name】	Noritaka Yamada
【Applicant】	
【ID No.】	000003207
【Name】	Toyota Jidosha Kabushiki Kaisha
【Agent】	
【ID No.】	100071216
【Patent Attorney】	
【Name】	Masaki Akashi
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[Title of the document] Specification

[Title of the invention] Behavior control device of vehicles

[Claims]

[Claim 1]

A behavior control device of vehicles, comprising a rolling-over liability index calculation means for calculating a rolling-over liability index showing a liability of rolling-over of a vehicle, and a deceleration application means for applying a deceleration to the vehicle when said rolling-over liability index exceeds a threshold value, characterized by having a turning condition variation detection means for detecting a variation of a turning condition of the vehicle, and a deceleration adjustment means for decreasing the deceleration applied to the vehicle when the variation of the turning condition is smaller than when the variation of the turning condition is larger.

[Claim 2]

A behavior control device of vehicles according to claim 1, characterized in that said deceleration application means applies a deceleration to the vehicle by controlling a braking means of the vehicle.

[Claim 3]

A behavior control device of vehicles according to claim 1 or 2, characterized in that the variation of the turning condition is a steering angular velocity.

[Claim 4]

A behavior control device of vehicles according to claim 1 or 2, characterized in that the variation of the turning condition is in either a steering angular velocity or a filtered value of the steering angular velocity which is larger than the other.

[Detailed descriptions of the invention]

[0001]

[Field of the invention]

The present invention relates to a behavior control device of vehicles, and more particularly to a behavior control device of vehicles for preventing a rolling-over of a vehicle by applying a deceleration to the vehicle as required.

[0002]

[Prior art]

As one of the behavior control devices for preventing a rolling-over of a vehicle such as an automobile, as described in, for example, Japanese Patent Laid-open Publication Hei 6-297985 filed by the same applicant as the present application, there is known a behavior control device adapted to estimate a liability of rolling-over of a vehicle, and to decelerate the vehicle by automatically actuating a braking means when the vehicle is liable to roll over.

[0003]

According to the behavior control device of the above-mentioned prior proposal, when, for example, the vehicle is liable to roll over by an application of an excessive centrifugal force to the vehicle as in a quick turning of the vehicle, the braking means is automatically actuated regardless of the braking action of the driver, whereby the vehicle is decelerated to decrease the centrifugal force applied to the vehicle, resulting in a prevention of the rolling-over of the vehicle.

[0004]

[Problems to be solved by the invention]

However, in the above-mentioned prior art behavior control device, since the deceleration applied to the vehicle when it is liable to roll over is constant, when the deceleration applied to the vehicle is set at a high value in order to effectively prevent the rolling-over of the vehicle, the deceleration applied to the vehicle during a normal turn or the so-called J turn of the vehicle becomes excessive, thereby causing problems such as a jerking of the steering wheel or a bulging of the vehicle to the outside of a normal turning curve.

[0005]

In order to prevent the above-mentioned problems, if the deceleration applied to the vehicle is set at a lower value when the vehicle is liable to roll over, the deceleration of the vehicle is insufficient in an early stage of an emergency avoiding steering, causing a problem that the stability of the vehicle is not satisfactorily ensured.

[0006]

The present invention was made in view of the above-mentioned problems in the prior art behavior control device constructed to apply a constant deceleration to the vehicle when it is liable to roll over. A principal object of the present invention is to variably control the deceleration applied to the vehicle according to the degree of the variation of the turning condition of the vehicle, so that the stability of the vehicle is desirably ensured, preventing the rolling-over of the vehicle with no jerking of the steering wheel or a bulging out of the vehicle from a normal turning curve.

[0007]

[Means to solve the problems]

According to the present invention, the above-mentioned principal object is accomplished by the construction of claim 1, that is, a behavior control device of vehicles, comprising a rolling-over liability index calculation means for calculating a rolling-over liability index showing a liability of rolling-over of a vehicle, and a deceleration application means for applying a deceleration to the vehicle when said rolling-over liability index exceeds a threshold value, characterized by having a turning condition variation detection means for detecting a variation of a turning condition of the vehicle, and a deceleration adjustment means for decreasing the deceleration applied to the vehicle when the variation of the turning condition is smaller than when the variation of the turning condition is larger.

[0008]

According to the construction of claim 1, the variation of the turning condition of the vehicle is detected, and when the variation of the turning condition is small, the deceleration applied to the vehicle is set at a low value as compared with a case when the variation of the turning condition is large, so that a sufficient deceleration is applied to the vehicle in an early stage of an emergency avoiding steering thereby enabling to ensure the stability of the vehicle, while the deceleration applied to the vehicle in a normal turning or J turn of the vehicle is decreased, so that a jerking of the steering wheel or a bulging out of the vehicle from a normal turning curve is prevented.

[0009]

Further, according to the present invention, in order to effectively accomplish the above-mentioned primary object, in the construction of claim 1, the above-mentioned deceleration application means is constructed to apply a deceleration to the vehicle by controlling a braking means of the vehicle. (Construction of claim 2)

[0010]

According to the construction of claim 2, since the vehicles are generally equipped with braking means, when the deceleration application means applies a deceleration to the vehicle by controlling the braking means of the vehicle, no particular device for applying a deceleration to the vehicle is required.

[0011]

Further, according to the present invention, in order to effectively accomplish the above-mentioned primary object, in the construction of claim 1 or 2, the variation of the turning condition is made to be a steering angular velocity. (Construction of claim 3)

[0012]

According to the construction of claim 3, since the variation of the turning condition is the steering angular velocity, the difference between an abrupt turning condition such as an emergency avoiding steering and a

moderate turning condition such as a normal turning or J turn is definitely judged.

[0013]

Further, according to the present invention, in order to effectively accomplish the above-mentioned primary object, in the construction of claim 1 or 2, the variation of the turning condition is made to be either the steering angular velocity or a filtered value of the steering angular velocity which is larger than the other. (Construction of claim 4)

[0014]

According to the construction of claim 4, since the variation of the turning condition is either the steering angular velocity or the filtered value thereof which is larger than the other, even when the steering angular velocity decreases before a turning of the steering wheel is returned, the deceleration applied to the vehicle does not too early and rapidly decrease, whereby it is made possible to more definitely prevent a rolling-over of the vehicle.

[0015]

[Preferred mode of the means for solving the problems]

According to a preferred mode of the present invention, in the construction of claim 1, the rolling-over liability index is a function of a lateral acceleration and a roll rate of the vehicle. (Preferred mode 1)

[0016]

According to another preferred mode of the present invention, in the construction of the above-mentioned preferred mode 1, the rolling-over liability index is an absolute value of a linear sum of the lateral acceleration and the roll rate of the vehicle. (Preferred mode 2)

[0017]

According to still another preferred mode of the present invention, in the construction of claim 1, the deceleration application means is constructed to apply a deceleration to the vehicle when a ratio of the rolling-over liability

index to a predetermined standard value therefor exceeds a predetermined value. (Preferred mode 3)

[0018]

According to still another preferred mode of the present invention, in the construction of claim 1, the deceleration adjustment means is constructed to set the deceleration applied to the vehicle to be larger as the variation of the turning condition is larger. (Preferred mode 4)

[0019]

According to still another preferred mode of the present invention, in the construction of claim 4, the filtering process for obtaining the filtered value of the steering angular velocity is constructed to moderately process the variation of the steering angular velocity. (Preferred mode 5)

[0020]

[Embodiment of the invention]

In the following, the present invention will be described with respect to a preferred embodiment thereof by referring to the accompanying drawings.

[0021]

Fig. 1 is a diagrammatical view showing an embodiment of the behavior control device of vehicles according to the present invention.

[0022]

In Fig. 1, 10FL and 10FR indicate front left and right wheels of a vehicle 12, and 10RL and 10RR indicate rear left and right wheels which are driving wheels of the vehicle. The front left and right wheels 10FL and 10FR which are driven and steered wheels are steered by a rack-and-pinion type power steering device 16 driven in response to a steering turning of a steering wheel 14 by a driver via tie rods 18L and 18R.

[0023]

Braking forces of the respective wheels are controlled by controlling braking pressures of wheels cylinders 24FR, 24FL, 24RR and 24RL by an

oil-hydraulic circuit 22 of a braking device 20. Although not shown in the figure, the oil-hydraulic circuit 22 comprises a reservoir, an oil pump and various valves, etc., and it is normally controlled by a master cylinder 28 driven in accordance with a depressing operation of a brake pedal 26 by the driver, while it is also controlled by an electric control device 30 when required as described in detail hereinunder.

[0024]

For the wheels 10FR-10RL there are provided wheel speed sensors 32FR, 32FL, 32RR and 32RL for detecting respective wheel speeds Vwi (i=fr, fl, rr and rl). A steering angle sensor 34 is provided at a steering column connected to the steering wheel 14 so as to detect a steering angle θ. A lateral acceleration sensor 36 and a roll rate sensor 38 are mounted to the vehicle 12 for detecting a lateral acceleration Gy and a roll rate Rra of the vehicle, respectively. The steering angle sensor 34, the lateral acceleration sensor 36 and the roll rate sensor 38 detect the steering angle, the lateral acceleration and the roll rate to be positive when the vehicle makes a left turn.

[0025]

As shown in Fig. 1, the signals showing the wheel speed Vwi detected by the wheel speed sensors 32FR-32RL, the signals showing the steering angle θ detected by the steering angle sensor 34, the signal showing the lateral acceleration Gy detected by the lateral acceleration sensor 36, and the signal showing the roll rate Rra detected by the roll rate sensor 38 are input to the electric control device 30. Although not shown in detail in Fig. 1, the electric control device 30 includes, for example, CPU, ROM, RAM and input and output port means constructed to a micro computer of a conventional construction in which those components are mutually connected by a bi-lateral common bus.

[0026]

According to the flowchart shown in Fig. 2 described hereinunder, the electric control device 30 calculates a rolling-over liability index Vr showing the

liability of the vehicle to roll over based upon the lateral acceleration Gy and the roll rate Rra of the vehicle, judges if the liability of the vehicle to roll over is high or not according to a judgement if a ratio of the rolling-over liability index Vr to a predetermined standard value Vro (positive constant) predetermined therefor is larger than 1, calculates a target deceleration Gxa of the vehicle according to the magnitude of the steering angular velocity when the liability of the rolling-over of the vehicle is high, and controls the braking forces of the respective wheels based upon the target deceleration Gxa.

[0027]

In the following, the behavior control of the vehicle according to the shown embodiment will be described with reference to the flowchart of Fig. 2. The control according to the flowchart of Fig. 2 is started by a closing of an ignition switch not shown in the figure to be repetitively executed with a predetermined time interval.

[0028]

First in step 10, signals with regard to the wheel speeds Vwi and others are read in, and the rolling-over liability index Vr is calculated according to the following formula 1, with Ka and Kb being certain positive constants.

[0029]

$$Vr = | Ka \cdot Gy + Kb \cdot Rra | \ldots (1)$$

[0030]

In step 30, it is judged if the ratio of the rolling-over liability index Vr to the standard value Vro is larger than 1, i.e. if the liability of the vehicle to roll over is high or not. If the answer is yes, the control proceeds to step 50, while if the answer is no, the control proceeds to step 40 in which the respective wheel cylinders are connected to the master cylinder 28 so that the braking forces of the respective wheels are controlled according to the depression force applied to the brake pedal 26 by the driver.

[0031]

In step 50, the steering angular velocity θ d is calculated as a differentiation by time of the steering angle θ, for example, and in step 60 an absolute value θ da of the steering angular velocity θ d is calculated, also with a calculation of a filtered value θ daf of the absolute value θ da. In this connection, the filtering process of the absolute value θ da may be substituted by, for example, a calculation of a mean value of the absolute values of θ da of a predetermined number of past cycles and the absolute value θ da of the current cycle, as long as the filtering process is to moderate the variation thereof.

[0032]

In step 70, a larger of the absolute value of θ da of the steering angular velocity θ d and the filtered value θ daf thereof is obtained as a value θ damax, and a target deceleration Gxa of the vehicle is calculated based upon the value θ damax by referring to a map shown in Fig. 3.

[0033]

In step 90, target slip ratios Srai (i = fr, fl, rr and rl) of the respective wheels to accomplish the target deceleration Gxa of the vehicle are calculated according to the art well known in this art, and in step 100, an automatic braking control is executed so that the slip ratios of the respective wheels are to conform to the target slip ratios Srai.

[0034]

Thus, according to the shown embodiment, during a normal running of the vehicle such as a straight running or a moderate turn running wherein the rolling-over liability index Vr is not high, the judgment of step 30 is negative, whereby the braking forces of the respective wheels are controlled according to the depression of the brake pedal 26 by the driver.

[0035]

When the vehicle is liable to roll over in a normal turning or so-called J turn at a relatively high speed wherein the rolling-over liability index Vr

becomes relatively high, the answer of step 30 becomes positive, whereby steps 50-100 are executed, so that the vehicle is applied with a required deceleration, thereby definitely preventing the vehicle from rolling over. In this case, since the steering angular velocity θ d is small, so that the target deceleration Gxa of the vehicle is not set at a high value, it is definitely prevented that the steering wheel is jerked or the vehicle bulges out to the outside of the turning curve by an excessive deceleration of the vehicle.

[0036]

Further, when the vehicle is liable to roll over in an abrupt turning such as an emergency avoiding steering, the absolute value of the steering angular velocity θ d becomes high, so that in accordance therewith the target deceleration Gxa of the vehicle is set at a high value Gxa2, whereby the vehicle is applied with a sufficient deceleration in an early stage, whereby the vehicle is definitely prevented from rolling over, ensuring the stability of the vehicle.

[0037]

For example, Fig. 4 (A) shows an example of the changes of the steering angle θ in a case of an emergency avoiding steering, and Fig. 4 (B) shows the changes of the target deceleration Gxa under the situation of Fig. 4 (A). As will be understood from Fig. 4, since the target deceleration Gxa becomes the high value Gxa2 in an early stage of the emergency avoiding steering, the vehicle is effectively and definitely braked to definitely prevent the rolling-over of the vehicle.

[0038]

Fig. 5 (A) shows an example of the variation of the steering angle θ in a normal turning, and Fig. 5 (B) shows the variation of the target deceleration Gxa under the situation of Fig. 5 (A). As will be understood from Fig. 5, since the steering angular velocity θ d is substantially zero in a normal turning, the target deceleration Gxa of the vehicle is set at a low value Gxal, whereby it is definitely prevented that an excessive deceleration is applied to the vehicle.

[0039]

Particularly according to the shown embodiment, since in step 70 a larger one of the absolute value θ da of the steering angular velocity θ d and the filtered value θ daf thereof is obtained as the value θ damax, so that the target deceleration Gxa of the vehicle is calculated based upon the larger value θ damax by referring to the map shown in Fig. 3, it is prevented that the target deceleration Gxa becomes early and rapidly small when the absolute value θ da of the steering angular velocity θ d decreases, whereby the rolling-over of the vehicle is definitely prevented.

[0040]

For example, when the steering angular velocity θ d changes as shown in Fig. 6, if the target deceleration of the vehicle is calculated based upon the absolute value θ da of the steering angular velocity θ d, the target deceleration Gxa decreases early and rapidly when the absolute value θ da of the steering angular velocity θ d decreases as shown by a phantom line at the bottom of Fig. 6. In contrast, according to the shown embodiment, it is definitely avoided that the target deceleration Gxa decreases early and rapidly when the absolute value θ da of the steering angular velocity θ d decreases, as shown by the solid line at the bottom of Fig. 6.

[0041]

Further, according to the shown embodiment, since the target deceleration Gxa is not changed according to the rolling-over liability index Vr but is changed according to the larger one of the absolute value θ da of the steering angular velocity and the filtered value θ daf thereof, it is definitely judged if the vehicle is in a rapidly turning condition such as an emergency avoiding steering or in a moderate turning condition such as a normal turning or J turn, whereby the vehicle is applied with a proper deceleration according to the judgment.

[0042]

Although the present invention has been described in detail with respect to a particular embodiment thereof in the above, it will be apparent for those skilled in the art that the present invention is not limited to the shown embodiment, but can be carried out in other various embodiments within the scope of the present invention.

[0043]

For example, although in the above-mentioned embodiment the rolling-over liability index Vr showing the rolling-over liability of the vehicle is calculated as a linear sum of the lateral acceleration Gy and the roll rate Rra of the vehicle, with the roll rate Rra being detected by the roll sensor 38, the rolling-over liability index Vr may be calculated by any manner known in this art, while the roll rate Rra may be calculated based upon, for example, variation of vehicle height at the respective wheels.

[0044]

Further, although in the above-described embodiment, in step 90, the target slip ratios Srai of the respective wheels are calculated based upon the target deceleration Gxa of the vehicle, so that the braking means are controlled to make the actual slip ratios of the respective wheels to conform to the target slip ratios Si, the deceleration may be controlled according to any means or manner as long as the deceleration of the vehicle is made to the target deceleration Gxa, while the output of an engine not shown in the figure may be controlled in addition to the braking means.

[0045]

[Effects of the invention]

As will be apparent from the above descriptions, according to the construction of claim 1, the stability of the vehicle is ensured by applying a sufficient deceleration to the vehicle in an early stage of an emergency avoiding steering, while the deceleration applied to the vehicle is decreased in a normal turning or J turn of the vehicle, so that it is definitely prevented that the steering

wheel is jerked or the vehicle bulges to the outside of the turning curve.

[0046]

Further, according to the construction of claim 2, since the deceleration application means applies the deceleration to the vehicle by controlling the braking means of the vehicle, no particular device is required for applying the deceleration to the vehicle, thereby accomplishing the effect of claim 1 without causing any cost-up.

[0047]

Further, according to the construction of claim 3, since the variation of the turning condition is the steering speed, it is definitely judged if the turning condition is an emergency avoiding steering or a normal turning or J turn of the vehicle, whereby a proper deceleration is definitely accomplished according to the turning condition of the vehicle.

[0048]

Further, according to the construction of claim 4, since the variation of the turning condition is a larger one of the variation of the steering rate and the filtered value thereof, even when the steering angular velocity becomes small before a turning of the steering wheel is returned, the deceleration applied to the vehicle does not early and quickly decrease, whereby the rolling-over of the vehicle is more definitely prevented.

[Brief description of the drawings]

[Fig. 1]

A diagrammatical view showing an embodiment of the behavior control device of vehicles according to the present invention.

[Fig. 2]

A flowchart showing the behavior control routine in the shown embodiment.

[Fig. 3]

A graph showing the relationship between the absolute value of the

steering angular velocity θ d and the target deceleration Gxa of the vehicle.

[Fig. 4]

(A) shows an example of the variation of the steering angle θ in an emergency avoiding steering, and (B) is a graph showing the variation of the target deceleration Gxa under the situation of (A).

[Fig.5]

(A) shows an example of the variation of the steering angle θ in a normal steering, and (B) is a graph showing the variation of the target deceleration Gxa under the situation of (A).

[Fig. 6]

A set of graphs showing an example of the steering angular velocity θ d in a quick steering, the absolute value θ da of the steering angular velocity θ d, the filtered value θ daf of the absolute value θ da of the steering angular velocity, a larger value θ dmax of the absolute value θ da and the filtered value θ daf, and the variation of the target deceleration Gxa.

[Explanation of reference numerals]

10FR-10RL ... wheels

20 ... braking means

28 ... master cylinder

30 ... electric control device

32FR-32RL ... wheel speed sensors

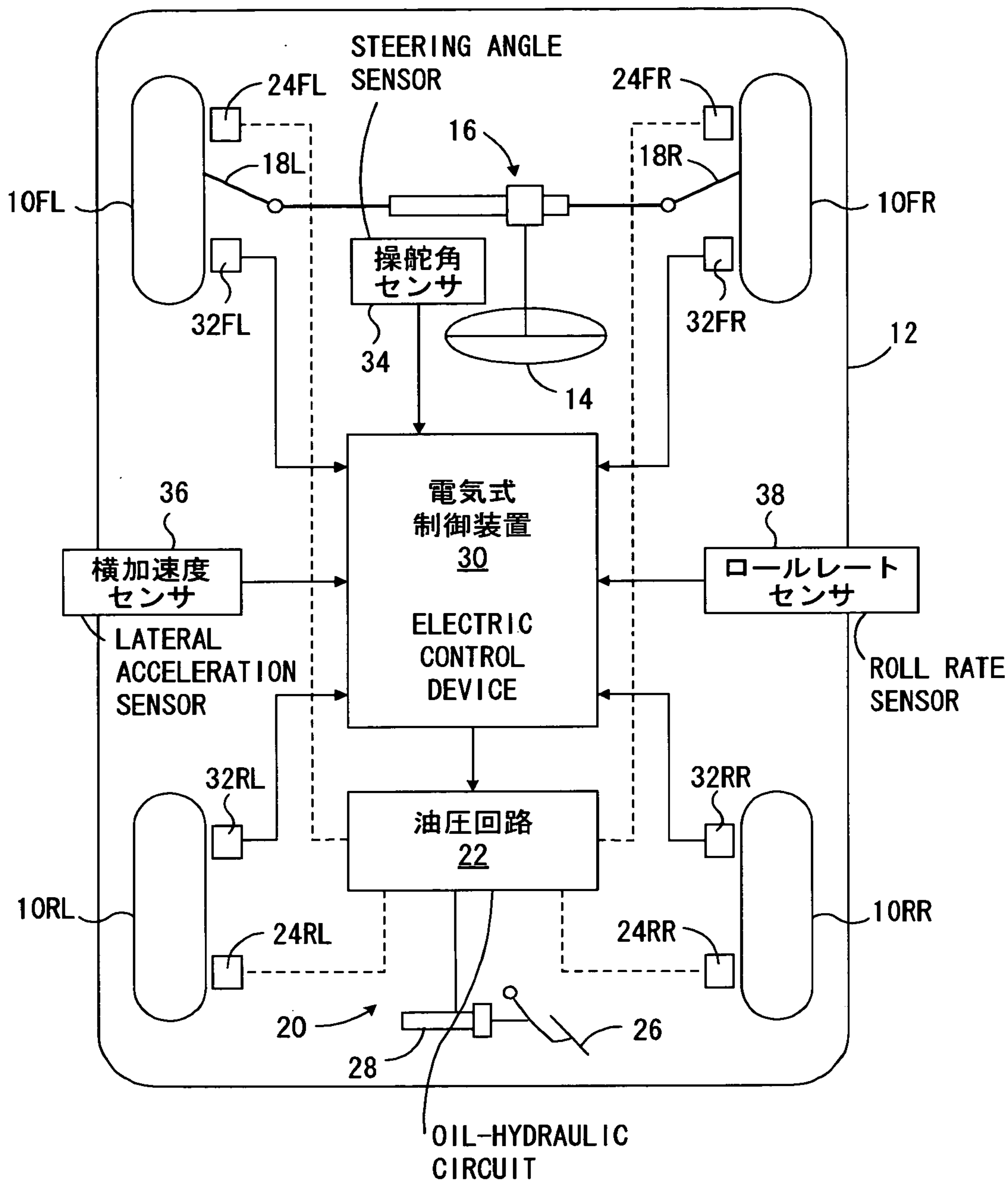
34 ... steering angle sensor

36 ... lateral acceleration sensor

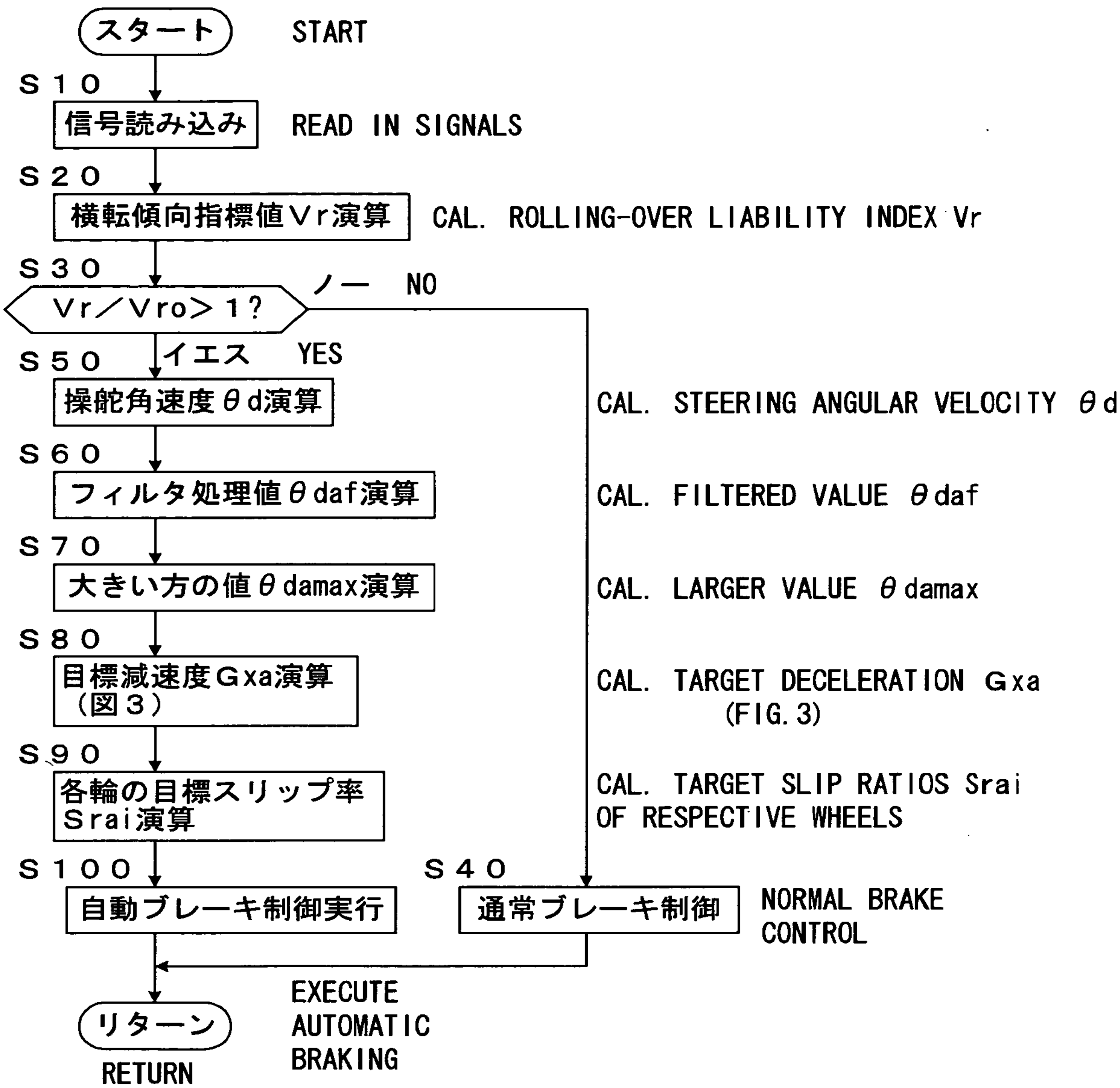
38 ... roll rate sensor

【書類名】 図面　　TITLE OF THE DOCUMENT: DRAWINGS

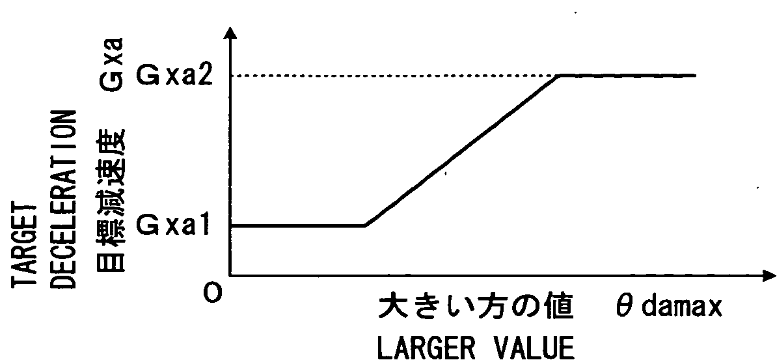
【図 1】　　FIG.1



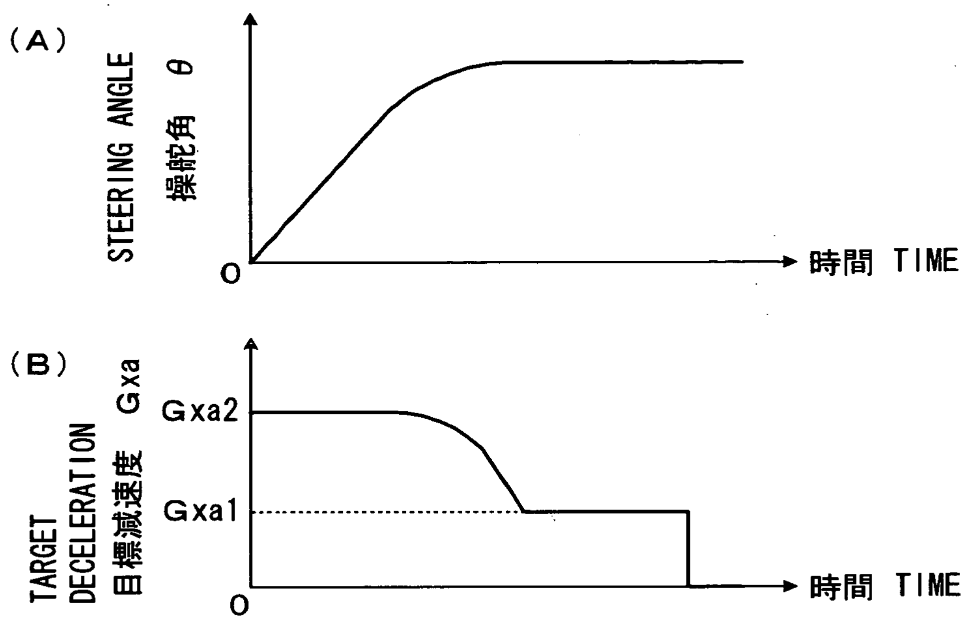
【図　2】 FIG. 2



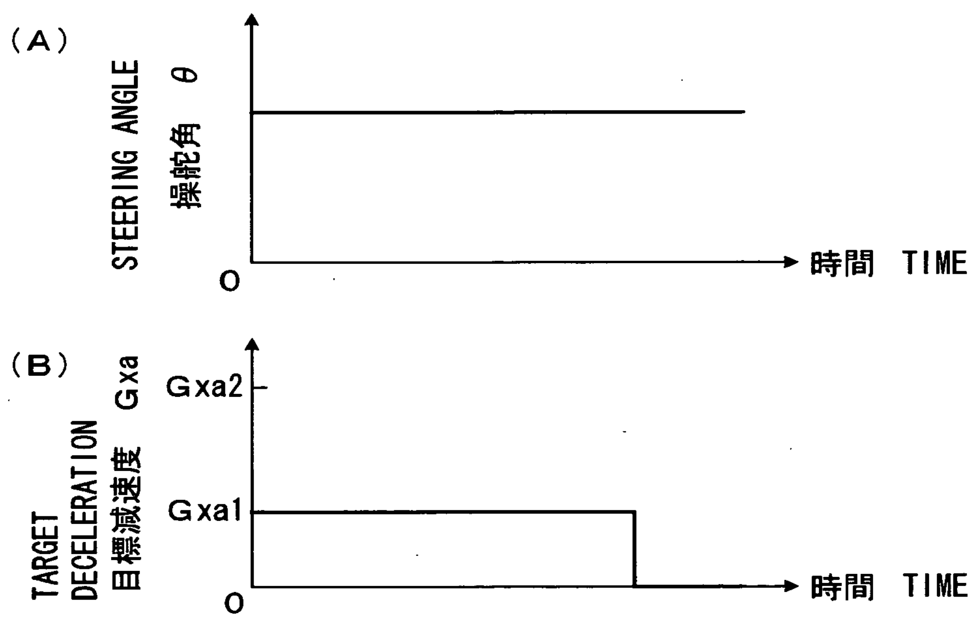
【図　3】 FIG. 3



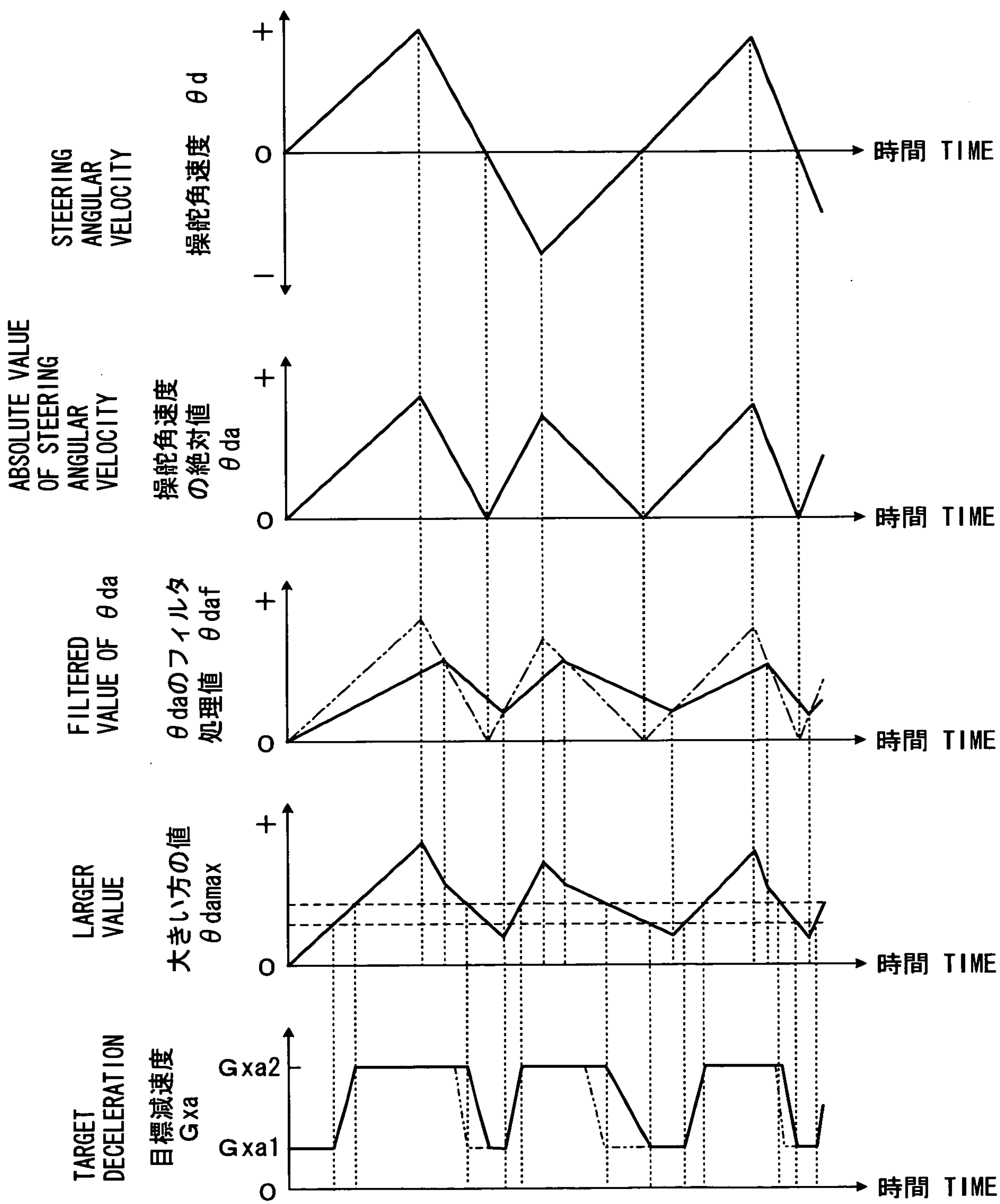
【図 4】 FIG. 4



【図 5】 FIG. 5



【図 6】FIG. 6



STEERING ANGULAR VELOCITY
操舵角速度 θd
ABSOLUTE VALUE OF STEERING ANGULAR VELOCITY
操舵角速度の絶対値 θda
FILTERED VALUE OF θda
θdaのフィルタ処理値 θdaf
LARGER VALUE
大きい方の値 θdamax
TARGET DECELERATION
目標減速度 Gxa
Gxa2
Gxa1
+
−
0
時間 TIME

[Title of the document] Abstract

[Abstract]

[Object]

To prevent the rolling-over of the vehicle by ensuring a good stability of the vehicle, with a prevention of the steering wheel being jerked or the running trace of the vehicle bulging to the outside of the turn.

[Solving means]

A rolling-over liability index Vr is calculated (S20), it is judged if the liability of the vehicle to roll over is high or not based upon the rolling-over liability index Vr (S30) when the liability of the rolling-over is high, a steering angular velocity θ d is calculated (S50), a filtered value θ daf of the absolute value of the steering angular velocity is calculated (S60), and a larger one of θ d and θ daf is obtained as θ damax (S70). Then, a target deceleration Gxa of the vehicle is calculated based upon θ damax to be higher as the value θ damax is higher (S80), and the braking forces of the respective wheels are controlled to decelerate the vehicle so that the deceleration of the vehicle conforms to the target deceleration Gxa (S90, 100).

[Figure elected] Fig. 2

[Name of document]	Official Correction Data
[Corrected document]	Patent Application

(Certified Information • Additional Information)

[Applicant]

[ID Number]	000003207
[Address]	1, Toyota-cho, Toyota-shi, Aichi-ken
[Name]	Toyota Jidosha Kabushiki Kaisha

[Agent]	Applicant
[ID Number]	100071216
[Address]	Akashi & Co., 5F YH Bldg., 2-6-8 Shinkawa, Chuo-ku, Tokyo
[Name]	Masaki Akashi

Information about Applicant's History

ID Number [000003207]

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   [Reason for change] New registration

   Address 1, Toyota-cho, Toyota-shi, Aichi-ken
   Name Toyota Jidosha Kabushiki Kaisha